Explaining the spatial variability of the mid-summer drought over the

Inter-American Seas region

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CPPA Proposal GC07-516: First year progress report

Overview of problem

Nearly 100 million people in at least 10 countries from southern Mexico to northern South America are affected by what is locally termed the "canicula" or in recent meteorological literature the "mid-summer drought" (MSD). Rainfall over many parts of this region shows two distinct peaks in monthly mean rainfall. The MSD is the period of lesser rainfall, varying between a month and three or four months duration, that occurs between an early wet-season and late season maxima in monthly mean rainfall at many sites. The intensity of this bimodal rainfall pattern is highly variable in space, and although there have been a number of detailed descriptions of the patterns from climatological rainfall data, a fully satisfactory explanation for the observed spatial patterns and their cause has not been presented. It is our hypothesis that most of the patterns of the MSD can be explained as the interaction of topography and the varying trade wind flow.

Summary of first year's work:

Our initial effort was to produce a depiction of the mean cloudiness and its evolution during the onset and decay of the MSD. Although there are different products that could be used as proxies for convective activity and rainfall (NCEP/CPC, OLR), the ISCCP B1 data provided unprecedented long-term records with relatively high spatial (~10 km) and temporal (3-hrly) resolution. The manipulation of the ISCCP B1 data has produced some unforeseen problems with the volume of the data, the navigation of the images, and the quality control of the data. For example, some extensive pre-processing was necessary in order to provide homogeneous data with acceptable geo-location of the images; these problems were a consequence of working with imagery from multiple satellites with various viewing angles.

We have continued to work with the 250 m MODIS imagery, and we have developed 4 year-composites of the cloudiness from which the evolution of the monthly mean cloudiness has been obtained. Despite the limited record there is good agreement with the 17-year GOES results, so that the MODIS results can be used to downscale the GOES 10 km results.

Our third area of work has been in comparing the NARR and NCEP reanalyses with in-situ measurements in Central America, specifically the pilot balloon soundings of gap flow across Nicaragua and southern Mexico.

Data

The satellite imagery analyzed here are the GOES 7,MET-3, GOES-8 and GOES-12 products obtained from the International Satellite Cloud Climatology Project (ISCCP) (Knapp, 2004; ISCCP B1U http://www.ncdc.noaa.gov/oa/ rsad/gibbs/gibbs.html.) These data, available from 1990 to 2006, are used here to facilitate the identification of enhanced maritime and continental convective activity in the region associated with MSD. This satellite imagery data base is used here as proxy for convective activity in the form of brightness temperature and IR cloud-top temperature thresholds in order to detect high, potentially precipitating clouds; we have initially used -38, -52 and -65°C.

Preliminary Results

Spatial variability of MSD from ISCCP data

A simple indicator of the onset of the midsummer drought over most of Central America and southern Mexico is the change in precipitation from June to July. We have not yet used precipitation data available for the region; as a surrogate the cloudiness from the GOES data set has been used (Fig. 1). This provides the broad perspective on the major cloudiness changes during the onset of the MSD. The large increase in cloudiness along the Sierra Madre Occidental in NW Mexico is obvious, as is the decrease in cloudiness over the central and western US. What is normally termed the MSD is associated with the decrease in cloudiness (increased brightness temperature) over the Pacific slopes from southern Mexico to northern Cost Rica. The Caribbean slopes show an enhancement in cloudiness. The largest MSD signal in Fig 1 is in El Salvador and extreme NW Nicaragua – regions that show strong MSD signals from rainfall data.

Also apparent from Fig 1 is the large amorphous regions of mostly smaller decreases extending from the central Atlantic to Central America and including large parts of northern South America. The significance of these mean patterns has yet to be determined.

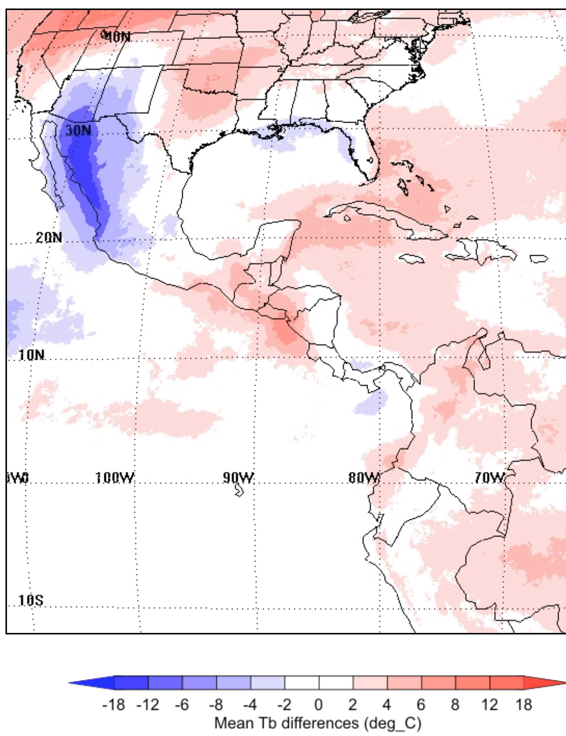

Fig. 1. Multiyear mean of June minus July brightness temperature. Mean values calculated using 17 years from 1990 to 2006 and 8-daily imagery (~ no diurnal cycle biases).

We are developing MSD indices; one simple one that uses monthly mean brightness temperatures (or also cloudiness frequencies) is:

MSD index = [(June+Sept)-(July+August)]/ [June+Sept+July+August],

where brackets denotes the mean.

Fig. 2 shows the pattern of this index based on the average of 17 years of monthly mean GOES brightness temperatures. This index should work well where the minimum in cloudiness is in July and August, as is the case in much of southern Mexico and Central America. It does not reflect the MSD in areas where the June and September are not months of peak cloudiness – such as over the Amazon

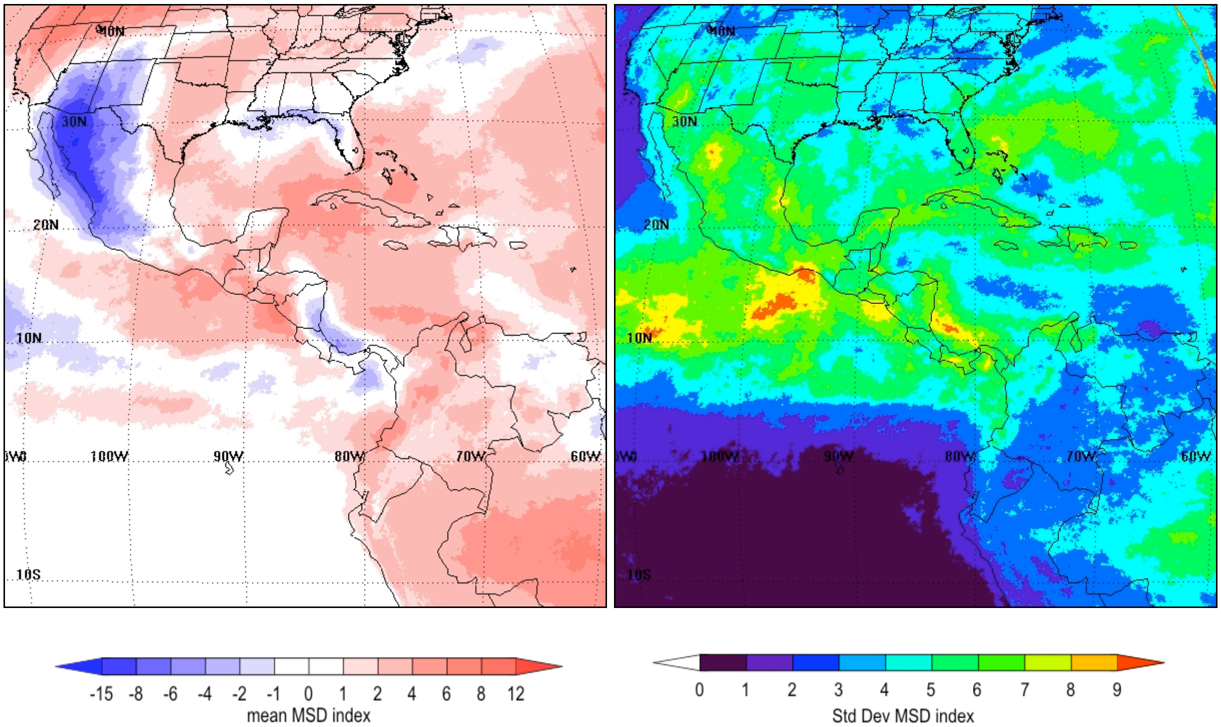

Fig. 2. MSD index (left) and standard deviation of index (right). Blue MSD values reflect areas with peak cloudiness in July-August, red are minima in cloudiness during these months.

Basin. Many features are similar to those seen in Fig 1, but the relationship between the topography of Central America and the cloudiness is more apparent in Fig. 2 – especially the contrast across the two prominent gaps at the Isthmus of Tehuantepec and across Nicaragua. The interannual variability of the MSD index (right panel of Fig 2) shows interesting spatial variations, but the significance of these have not yet been determined.

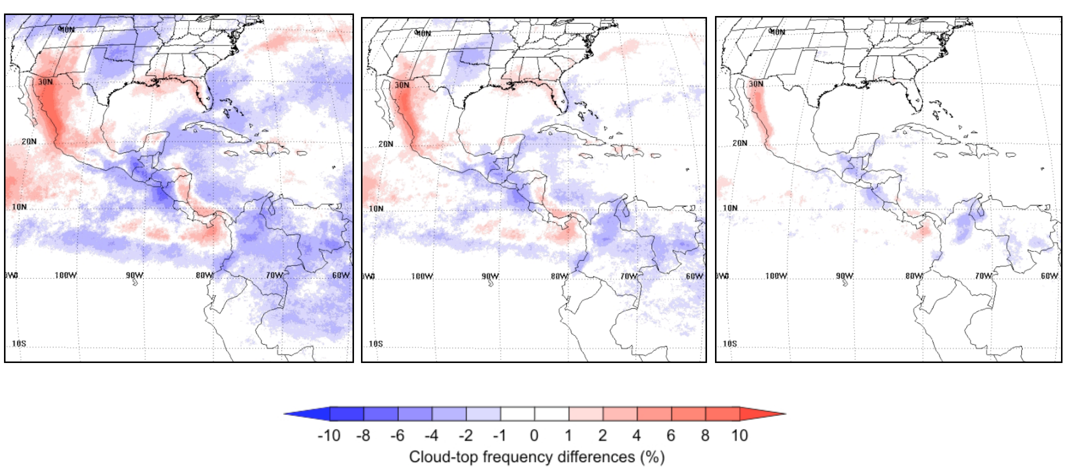

Fig. 3. Cloud –top temperature frequency for July minus June monthly means for different temperature thresholds: left) -38, center) -52 and right) -65°C.

We are investigating the relationship between convection and the MSD by stratifying the cloudiness frequencies by threshold temperature (Fig. 3). This is just beginning, but should help determine whether the MSD rainfall modulation is effected primarily by control of the intensity of convection or by the frequency of convective events.

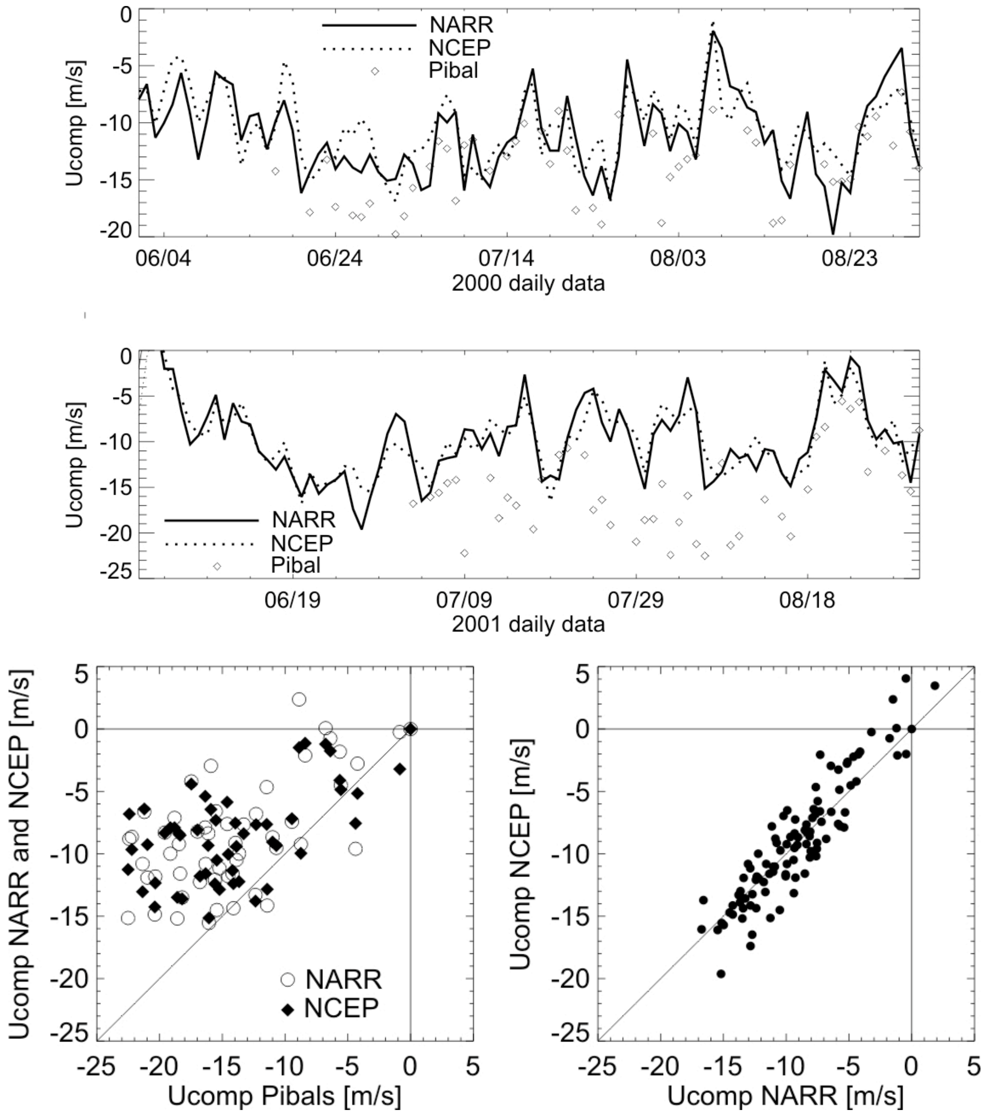

Fig. 4. top: Comparison of pilot balloon zonal winds at Managua during period July-August 2000 and 2001 with NARR and NCEP reanalysis winds. bottom: left) Scatterplot of pilot balloon u-winds versus NARR and NCEP u-winds and right) u-NARR vrs u-NCEP showing close agreement.

Future plans

1. Better define the domain of the MSD beyond the simple criteria used so far – and evaluate the satellite signature of the MSD based on different temperature thresholds (proportional to intensity of convective storms).

2. Exploit the in-situ sounding data (radiosonde and pilot balloon) to verify NARR-based signals of MSD.

3) Use the detailed rainfall data available for southern Mexico to validate the high resolution (MODIS-based) cloudiness signals associated with the MSD.

4) Develop composites of cloudiness over Central America based on synoptic trade wind intensity during the MSD period to evaluate the contribution of synoptic variations in the trade winds to the mean MSD climatology.

Acknowledgement

Ken Knapp from NCDC has graciously supplied the GOES imagery used in our study and MODIS imagery has been downloaded from a NASA website.

Reference

Knapp, K. R., 2004: ISCCP B1 Data at NCDC: A new climate resource. 13th Satellite Meteorology and Oceanography Conference, Norfolk, VA, American Meteorological Society.